ACARINA ASSOCIATED WITH DECOMPOSING FOREST LITTER IN THE NORTH CAROLINA PIEDMONT[1]

By

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INTRODUCTION

The forest floor is one of the most important yet most neglected components of the forest environment. The manipulation of this layer, from the topmost litter to the mineral soil, is the major way forest soil can be modified and productivity maintained. The intensive practices of agriculture—for example, plowing, contouring, and application of fertilizers—cannot be economically applied to forest land.

As a storehouse of nutrients, the forest floor is an important segment of the nutrient cycle, and maintains the fertility of the site by releasing nutrients from fallen debris to the surface of the mineral soil. These nutrients have been brought up from the lower layers of the soil profile by the tree roots.

The forest floor influences the water cycle by acting as a reservoir and by reducing evaporation losses. It ameliorates the microclimate of the surface soil by keeping it relatively cool in the summer and warm in the winter. The loosening effect of the organic debris on the surface mineral soil improves physical properties, such as porosity and aggregation, and these in turn permit more rapid intake of water. The floor arrests erosion by absorbing the kinetic energy of the raindrops.

Although the forest floor appears to be dead organic debris, it is in reality teeming with life. The organisms inhabiting it help produce its beneficial influence on the site. Acarina constitute a large part of the myriad small animals which live there. Their presence during decomposition play a role in this segment of the nutrient cycle. The objective of this study was to determine the abundance of certain Acarina in three species of decomposing leaves in a pine and a hardwood stand.

METHODS

Envelopes, 18 by 18 cm, were made of fiberglas window screen (openings about 1.5 mm square). The decomposition of this screen was slight; after 42 months in the field the average loss of weight was less than 4 percent. Known weights of freshly-fallen leaves of loblolly pine (*Pinus taeda* L.), white oak (*Quercus alba* L.), and flowering dogwood (*Cornus florida* L.) were placed in the envelopes. Air-dry leaves were used, but the oven-

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dry weight (60°C) was determined by drying ten samples from the supply of leaves used. Envelopes were identified with a small numbered aluminium tag on one corner. Leaf material was placed in 312 envelopes, and the edges were sealed by fusing with a hot iron.

One half of the envelopes of each leaf species were placed on the forest floor in a loblolly pine stand and half in a hardwood stand near Raleigh, North Carolina, in November, 1961. Because autumn leaf fall had begun the envelopes were placed beneath the recently fallen litter (Fig. 1).

FIG. 1. Preliminary layout of envelopes in the pine stand. They were finally placed about one meter apart, anchored in place with a wire, and covered with recently fallen needles. Envelopes were lifted in a random manner

Each sampling time (see Table 2), three envelopes of each leaf species were lifted from the two stands, making a total of 18 envelopes. The envelopes were cut open and litter and envelope placed on a modified Tullgren funnel for seven days. At the end of this period, the litter and envelopes were dried to a constant weight in an oven and weight loss was determined.

The envelopes were collected over a period of 42 months and were left undisturbed until collected. As additional litter fell, more material covered the envelopes and the last set picked up was buried several inches below the surface of the forest floor.

This litter-envelope method was patterned, in general, after that of CROSSLEY and HOGLAND (1962) at Oak Ridge, Tennessee.

RESULTS

Phytoseiidae

Phytoseiids were the dominant mesostigmatid family and 14 species were collected (Table 1). Of the adults, 57 percent were *Amblyseiulus detritus* Muma.

TABLE 1. Total numbers of phytoseiid adults collected in litter envelopes placed on the forest floor in a pine and hardwood stand in Umstead State Park near Raleigh, North Carolina

Species	♀	♀̄	♂	Total
Amblyseiulus detritus Muma	688	130	212	1030
Amblyseius floridanus (Muma)	146	42		188
Typhlodromips umsteadi Muma	114	27	31	172
Typhlodromips vicinus Muma	118	29	16	163
Amblyseiulus mexicanus (Garman)	95	22	4	121
Amblyseius punctatus Muma	64	18	21	103
Amblyseiodes curiosa Chant	18	1	2	21
Iphiseius arenicolus (Muma)	9			9
Amblyseiulus macrosetae Muma	7	1		8
Iphiseiodes hystrix (Muma)	3			3
Amblyseiulus tubulus Muma	2			2
Amblyseiulus carolinianus Muma	1			1
Galendromus mcgregori (Chant)	1			1
Phytoseius macropilis (Banks)	1			1
TOTAL	1265	271	286	1822

♀̄ = gravid female.

Of the 1822 phytoseiids collected, 60 percent were females without visible eggs, 15 percent were gravid females, and 16 percent were males (Table 1). Of the total females, 18 percent were gravid when taken. Of the six dominant species, males were absent only in *Amblyseius floridanus* (Muma), although they are known to exist (ATHIAS-HENRIOT 1958).

Of the six dominant species of phytoseiids taken, the adults of *A. detritus*, *Typhlodromips umsteadi* Muma, and *Typhlodromips vicinus* Muma were equally abundant in the envelopes from the pine and hardwood stands. About 80 percent of the adults of *A. floridanus* were present in envelopes from the hardwood stand, and about 70 percent of the adults of *Amblyseiulus mexicanus* (Garman) were taken in the pine stand. One phytoseiid, *Amblyseius punctatus* Muma, was present only in the hardwood stand.

Within both the pine and hardwood stands, the six dominant species of phytoseiids were usually taken in larger numbers from the envelopes containing pine litter. However, fewer were found in the pine litter when the number of phytoseiids was calculated per unit of dry weight of litter in the envelope at the time of collection. For the collections of July, 1962 and July, 1963, when the phytoseiids were most common, there was 1.0 phytoseiid per gram of pine litter and 2.3 per gram of oak and dogwood litter in the envelopes.

A. detritus was the most common phytoseiid collected (Table 1). Of the total adults, 67 percent were females without visible eggs, 13 percent were gravid females, and 20 percent were males. Of the total females, 16 percent were gravid.

Most *A. detritus* were from envelopes collected within the first two years after they were put on the forest floor (Table 2). The number collected later decreased. No *A. detritus* were recovered from the envelopes in place 42 months, even though the envelopes were collected during the period of abundance of this mite in previous years. Thus, *A. detritus* inhabited the less decomposed litter in the upper layers of this forest floor.

The period of greatest abundance of adults was from July through March, with a peak in November. Gravid *A. detritus* were most abundant in the spring and summer. The reproductive period of this species ranges mainly from March through September. During the winter months, the number of females taken at each collection time increased.

TABLE 2. Seasonal abundance of gravid females, females without eggs, and hardwood stands in Umstead State

Date Envelope Lifted	*Amblyseiulus detritus*				*Amblyseius floridanus*				*Typhlodromips umsteadi*			
	♀	♀̣	♂	Total	♀	♀̣	♂	Total	♀	♀̣	♂	Total
Jan. 1962	7			7								
Feb. 1962	14			14	1			1	1			1
Mar. 1962	18	16	3	37	2			2				
Apr. 1962	1	7		8								
May 1962		12	1	13		1		1				
July 1962	44	38	65	147	24	1		25			9	9
Sep. 1962	25	15	17	57	3			3	1	1	4	6
Nov. 1962	193	1	37	231	6			6	4		5	9
Jan. 1963	131		12	143	5			5	5		1	6
Mar. 1963	106		10	116	11			11	23		2	25
May 1963	18	23	27	68		4		4				
July 1963	13	10	19	42	43	26		69		2		2
Sep. 1963	16	4	8	28	7	1		8		4		4
Nov. 1963	60		6	66	15			15	22		3	25
Feb. 1964	40			40	17			17	53		2	55
May 1964	2	4	7	13					3	20	5	28
May 1965					12	9		21	2			2
Total	688	130	212	1030	146	42		188	114	27	31	172

♀̣ = gravid female

but no females containing eggs were taken, indicating a cessation of reproduction during that period in this species. Males were more abundant during the summer, sometimes exceeding the females early in the summer.

A. floridanus was the second most abundant phytoseiid taken in the envelopes (Table 1). All adults of *A. floridanus* were females, and 22 percent were gravid when collected.

A. floridanus became more abundant in the envelopes later, indicating the species inhabits the more decomposed litter in the lower layers (Table 2). More adults of it were present in the envelopes in place 42 months than adults of all other species of phytoseiids taken in that collection.

Females containing eggs were found only from May through September, with a peak in July. This was a shorter period of reproduction than was observed for *A. detritus*. Also in contrast to *A. detritus*, the number of *A. floridanus* decreased during the winter months.

Although more phytoseiids were usually present in the envelopes containing pine litter in both stands, *A. floridanus*, which was collected mainly from the hardwood stand, was an exception. In the pine stand, more of them were collected from the envelopes containing oak and dogwood litter than pine litter.

The total number of adult *T. umsteadi* taken in the envelopes was almost equal to the number of *A. floridanus* (Table 1). For females only, however, *T. umsteadi* more closely approximated the number of females of *T. vicinus* than that of *A. floridanus*. Of the total adults of *T. umsteadi*, 66 percent were females without eggs, 16 percent were gravid females, and 18 percent were males. Of the total females, 19 percent contained eggs.

T. umsteadi was taken mainly late in the collection period (Table 2). Population peaks were not wholly distinct, but larger numbers were taken in February and March. *T. umsteadi*, like *A. floridanus*, was taken from the more decomposed litter in the deeper levels. There was a peak abundance of females early in the year, and the species was about equally abundant in both pine and hardwood stands.

and males of the six most common phytoseiids present in litter envelopes in pine Park near Raleigh, North Carolina

Date Envelope Lifted		*Typhlodromips vicinus*				*Amblyseiulus mexicanus*				*Amblyseius punctatus*			
		♀	♀̣	♂	Total	♀	♀̣	♂	Total	♀	♀̣	♂	Total
Jan.	1962	1			1	5			5	2			2
Feb.	1962	1			1	3			3	1			1
Mar.	1962					5	4		9	6	5		11
Apr.	1962		2		2		7		7				
May	1962	1	1		2	3	3		6	4	7	1	12
July	1962	11	11	1	23	8	5	2	15	8	6	16	30
Sep.	1962	4	1		5					13		2	15
Nov.	1962	13		1	14	12		1	13	12		1	13
Jan.	1963	7			7	19			19	13			13
Mar.	1963	15			15	9			9	1			1
May	1963	2	1		3	3	1	1	5	1			1
July	1963	3	3	4	10	4	1		5				
Sep.	1963	3	3		6	3			3	2			2
Nov.	1963	31		6	37	9			9	1			1
Feb.	1964	19			19	10			10				
May	1964	7	5	3	15	2			2				
May	1965		2	1	3		1		1				
Total		118	29	16	163	95	22	4	121	64	18	21	103

♀̣ = gravid female

Of the total adults of *T. vicinus* taken, 72 percent were females without eggs, 18 percent were gravid females, and 10 percent were males (Table 1). Of the females, 20 percent contained eggs at the time of collection.

T. vicinus was taken slightly earlier in the sampling, indicating that it ranged higher in the less decomposed layer than *T. umsteadi* (Table 2).

Peak populations were present mainly during the late summer and fall. The peak population of females with eggs preceded the peak of abundance of the females.

T. vicinus tended to be more abundant in the envelopes taken from the pine stand.

Of the total adults of *A. mexicanus* taken, 79 percent were females containing no eggs, 18 percent were gravid, and 3 percent were males (Table 1). Of all the phytoseiids with males, *A. mexicanus* had the lowest percentage of males. Of the females taken, 19 percent were gravid.

Specimens of *A. mexicanus* were usually present in each collection and this species exhibited the least population fluctuation of any of the phytoseiids (Table 2). Slight population peaks occurred in the winter months. Females of *A. mexicanus* containing visible eggs were most abundant from March through July.

Over twice as many specimens of *A. mexicanus* were in the envelopes collected from the pine as from the hardwood stand.

Of the adults of *A. punctatus* taken, 62 percent were females without eggs, 18 percent were gravid females and 20 percent were males (Table 1). Of the females, 22 percent were gravid when collected.

Most of the specimens were collected from envelopes that had been in place from 9 to 14 months (Table 2). The peak of abundance was from July through January following placement of the envelopes. The population of *A. punctatus* was limited mainly to upper and less decomposed levels of the litter layer. A reproductive period from March through July was indicated by the presence in the females of visible eggs.

Ascidae

A total of 1555 specimens of *Asca* was collected from the envelopes (Table 3). *Asca aphidioides* (L.), the most common species, accounted for 35 percent of the specimens, followed by *A. garmani* Hurlbutt with 20 percent, *A. neopallida* Hurlbutt with 18 percent, and *A. piloja* Hurlbutt with 1 percent. The nymphs, not determinable by species, accounted for 26 percent of all specimens. For all species combined, 62 percent were females without eggs, 9 percent were gravid females, 3 percent were males, and 26 percent were nymphs. Only 13 percent (197 mites) were collected from the pine stand and 87 percent (1358 mites) came from the hardwood stand. For the combined stands, 50 percent of the ascids were collected from the pine envelopes, 24 percent from the oak envelopes, and 26 percent from the dogwood envelopes. As with the phytoseiids, however, by calculating the number of ascids per gram of litter in the envelopes at time of collection, we found fewer ascids in the pine litter. For the collections of July, 1962 and July, 1963, when ascids were quite common, there were 1.1 per gram of pine litter, 1.4 per gram of oak, and 2.5 per gram of dogwood.

TABLE 3. Seasonal abundance of gravid females, females without eggs, and males of the genus *Asca* present in litter envelopes in pine and hardwood stands in Umstead State Park near Raleigh, North Carolina

Date Envelope Lifted	*Asca aphidioides*				*Asca garmani*				*Asca neopallida*				*Asca piloja*				Nymphs unidentified	Total
	♀	♀	♂	Total	♀	♀	♂	Total	♀	♀	♂	Total	♀	♀	♂	Tot.		
Jan. 1962																		
Feb. 1962	3			3					1			1						4
Mar. 1962	4	7		11	15	1		16	5			5						32
Apr. 1962	8			8	7	1		8	1			1						17
May 1962	3			3	1	1		2		2		2						7
July 1962	69	34		103	18	4		22	26	11	14	51		1		1	48	225
Sep. 1962	53	5		58	14			14	9		14	23					12	107
Nov. 1962	20	1		21	70			70	39		2	41	1			1		133
Jan. 1963	2			2	4			4	29			29					1	36
Mar. 1963	153	1		154	49	1		50	21			21	2			2	14	241
May 1963	20			20	7	1		8	5	10		15					43	86
July 1963	49	16		65	26	5	1	32	10	5	11	26					111	234
Sep. 1963	2			2	9			9	10		3	13	1			1	10	35
Nov. 1963	19			19	15	1		16	27		1	28					4	67
Feb. 1964	15			15	2			2	15			15	3			3		35
May 1964	31	4		35	27	4	1	32	2	11		13					154	234
May 1965	17	5		22	19	8		27	4	2		6	1			1	6	62
Total	468	73		541	283	27	2	312	204	41	45	290	8	1		9	403	1555

♀ = gravid female

There were 541 females of *A. aphidioides* collected, and 13 percent were gravid. The gravid females were collected from March through November, a period which agrees with HURLBUTT (1963). Population peaks were in July the first year and March the second year following placement of the envelopes. No males were collected.

Of the 312 adults of *A. garmani* collected, over 99 percent were females. This is the first time that males of this species have been reported. Nine percent of the females were gravid. Females were present throughout the year, but gravid females were found only from March through July. The reproduction period for *A. garmani* agrees with that of HURLBUTT (1963).

There were 290 adults of *A. neopallida* collected, and 16 percent were males. The gravid females, which constituted 17 percent of all females, were collected only in May and July.

The few *A. piloja* were collected throughout the year, and the one gravid female in this species occurred in July.

Nymphs, not determinable by species, were collected from January through November, with the greatest number occurring in July. HURLBUTT (1963) in Maryland found nymphs of *Asca* only from May to October.

Veigaiidae

TABLE 4. Total veigaiids collected in litter envelopes placed on the forest floor in a pine and hardwood stand in Umstead State Park near Raleigh, North Carolina

Species	♀	♀	♂	DN	PN	Total
V. mitis (Berlese)	26	13	16	42	13	110
V. partitus (Banks)	8	8		32	3	51
V. piliseta Farrier	1			4		5
TOTAL	35	21	16	78	16	166

♀ = gravid female
DN = deutonymph
PN = protonymph

TABLE 5. Seasonal abundance of gravid females, females without eggs, males, and nymphs of *Veigaia* present in litter envelopes in pine and hardwood stands in Umstead State Park near Raleigh, North Carolina

Date Envel. Lifted		*V. mitis*					*V. partitus*					*V. piliseta*					Total
		♀	♀	♂	DN	PN	♀	♀	♂	DN	PN	♀	♀	♂	DN	PN	
Jan.	1962							1									1
Feb.	1962							2									2
Mar.	1962																
Apr.	1962						1										1
May	1962									4							4
July	1962							3		5							8
Sep.	1962						1			2							3
Nov.	1962	14		7	1		4	2									28
Jan.	1963																
Mar.	1963		1	1													2
May	1963				6				6								12
July	1963	2	1	1	7	5				3	2	1					22
Sep.	1963																
Nov.	1963	1		3	1					1					3		9
Feb.	1964	1	2														3
May	1964	2	5		13	5				4					1		30
May	1965	6	4	4	14	3	2			7	1						41
	Total	26	13	16	42	13	8	8	6	26	3	1			4		166

♀ = gravid female
DN = deutonymph
PN = protonymph

Three species of *Veigaia* were collected in the envelopes (Table 4). *Veigaia mitis* (Berlese) and *V. partitus* (Banks) were the dominant species, with *V. mitis* twice as abundant as *V. partitus*.

Of the total adult veigaiids collected, 49 percent were females without eggs, 29 percent were gravid females, and 22 percent were males. Of the total females, 38 percent were gravid.

Of the total veigaiids taken, 143 (86 percent) were from the hardwood stand and 23 (14 percent) were from the pine stand.

For the adults of *V. mitis*, 47 percent were females containing no eggs, 24 percent were females with eggs, and 29 percent were males. Of the total females of this species, 33 percent were gravid.

Larger proportions of nymphs of all species of veigaiids were taken in later collections than were the adults (Table 5). Thus, the nymphs tend to inhabit a more decomposed lower level in litter than the adults.

Adults of *V. partitus* were more numerous in the early collections than *V. mitis* or *V. piliseta* Farrier, indicating that they inhabit a higher level of the forest floor than other veigaiids.

Mites in envelopes after exposure of 42 months in the forest

Of the mites collected in the envelopes picked up after 42 months exposure, 93 percent were Oribatei, 6 percent were Mesostigmata, and 1 percent were Trombidiformes. Nine families are represented in the 215 specimens of Mesostigmata collected, and eight

TABLE 6. Total numbers of mesostigmatid and trombidiform mites collected from eighteen envelopes of three leaf species after lying in the forest floor for 42 months

Taxon	Pine Stand	Hardwood Stand	Total Adults+Nymphs
Mesostigmata			
Ascidae	25	31 (6)*	62
Phytoseiidae	12 (4)	24 (1)	41
Veigaiidae	2 (4)	14 (21)	41
Parholaspidae	2 (2)	22 (3)	29
Zerconidae		26	26
Laelaptidae	3	3	6
Uropodidae		3 (3)	6
Aceosejidae	1	2	3
Digamasellidae	1		1
	171 adults plus 44 nymphs = 215		
Trombidiformes			
Bdellidae	6	1	7
Erythraeidae	2	2	4
Rhagidiidae	2	2	4
Stigmaeidae	3		3
Cryptognathidae	3		3
Cunaxidae		2	2
Pachygnathidae	1		1
Trombibulidae		(1)	1
	24 adults plus 1 nymph = 25		

* ( ) = nymph.

families were included in the 25 Trombidiformes collected (Table 6). Zerconids were taken only in the hardwood stand. Oribatids, the dominant group in this collection, were represented by 3145 specimens, of which about one fifth were nymphs. *Oppia* was the dominant

TABLE 7. Oribatids recovered from litter envelopes exposed in the forest floor for 42 months

Genus	Number	Genus	Number
Oppia	1035	Allodamaeus	6
Caleremaeus	573	**Hoplophthiracarus	6
Tectocepheus	323	Phthiracarus	6
Suctobelba	185	Oripoda	5
Belba	117	**Quadroppia	5
*Anachipteria	58	*Malaconothrus	4
**Eremaeus	54	Trimalaconothrus	3
Peloribates	52	**Microzetes	2
**Parachipteria	38	**Oribatella	2
Hoplophorella	33	**Trhypochthonius	2
Rhysotritia	32	*Trichoribates	2
Eupelops	27	**Xenillus	2
Carabodes	25	**Arcozetes	1
Ceratoppia	20	**Ceratozetes	1
*Cepheus	15	*Cultroribula	1
Galumna	14	*Gymnodamaeus	1
**Scheloribates	14	*Liacarus	1
Acaronychus	13	**Nanhermannia	1
**Hermaniella	13	*Oribatula	1
Rostrozetes	12	*Scapheremaeus	1
Dolicheremaeus	10		
		Oribatid adults	2716
		Oribatid nymphs	429
		Total Oribatids	3145

* Recovered from pine stand only.
** Recovered from hardwood stand only.

TABLE 8. Dry litter weights and oribatids recovered after 42 months in the field

Stand	Leaf Type	Initial Wt. of leaves*	Final wt. of decomposed leaves*	Oribatids per envelope*	Oribatids/gram of decomposing leaves
		grams	grams		
Pine	Pine	26.27	12.94	353	27
Pine	Oak	7.76	4.67	172**	36
Pine	Dogwood	6.20	1.43	29	20
Hardwood	Pine	30.22	16.87	397	23
Hardwood	Oak	8.25	3.19	120	38
Hardwood	Dogwood	6.34	1.71	34	20

* Average of three envelopes.
** Average of two envelopes.

genus of oribatids (Table 7). *Caleremaeus*, *Tectocepheus*, *Suctobelba*, and *Belba* were secondary genera. Nine genera were recovered only in the pine stand, 13 genera were recovered only in the hardwood stand, and 19 genera were common to both.

The number of oribatids recovered in the three types of leaves in each of the two stands is shown in Table 8. The number of mites per sample was proportional to the weight of the leaves in the envelopes, with a maximum difference in magnitude of 12. By calculating the number of oribatids per gram of leaves in the envelopes, however, the differences were reduced to a maximum of 2.

CONCLUSIONS

1. There was a succession of species of mesostigmatid mites present in tree leaves as they decomposed in the forest floor.

2. In the phytoseiids, one species was dominant, five were secondary, and eight others were present.

3. In the ascids, three species were dominant and one other was present. Males, heretofore not reported in the literature, were found for *Asca garmani*.

4. There were species differences in seasonal development, sex ratios, and times of reproduction for phytoseiids, ascids and veigaiids.

5. In the litter envelopes left in the forest floor for 42 months, 93 percent of the acari collected were oribatids, 6 percent were mesostigmatids, and 1 percent were trombidiform mites.

SUMMARY

Three species of tree leaves, confined in small fiberglas envelopes, were placed in a pine and a hardwood forest. Periodically, over a span of 42 months, a proportion of the envelopes were removed and the fauna extracted. As the leaves decomposed, there was a succession of species of phytoseiids, ascids, and veigaiids. Nine families of Mesostigmata, eight families of Trombidiformes, and 41 genera of Oribatei were represented in the final collection.

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